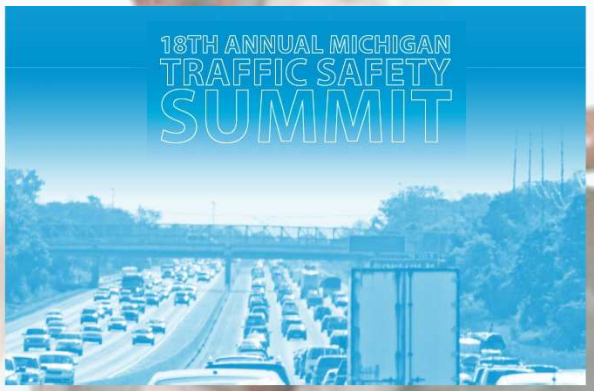
The Front Center Airbag

18th Annual Michigan Traffic Safety Summit

March 26, 2013



Scott Thomas

Senior Staff Engineer – General Motors, Advanced Restraint Systems

The Front Center Airbag

Agenda

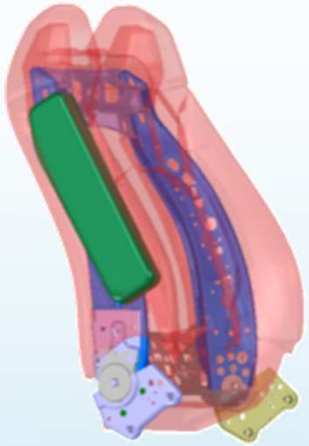
- Technology Development and Description
- Deployment Mechanization
- Performance Evaluation Overview
- Field Data Overview
- The Single Driver Occupant - Field Data And In-Position Performance
- Two Front Occupants – Field Data And In-Position Performance
- Summary

Technology Development

- The Front Center Airbag (which deploys from the front driver seat) was jointly developed by GM and Takata.
- Five joint GM-Takata module patent applications are in process.
- This technology is being implemented on GM's 2013 Midsize Crossover Vehicles.

Technology Description

Soft Pack Module

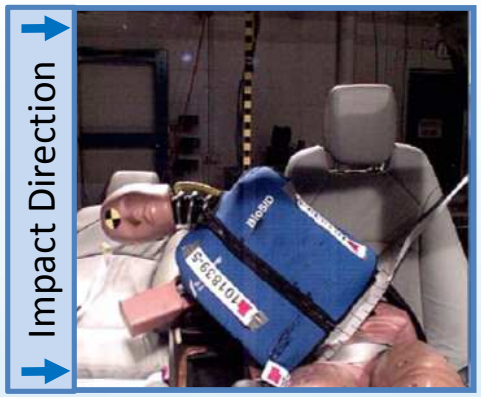


11 Liter Tubular Construction Cushion with Two Tethers

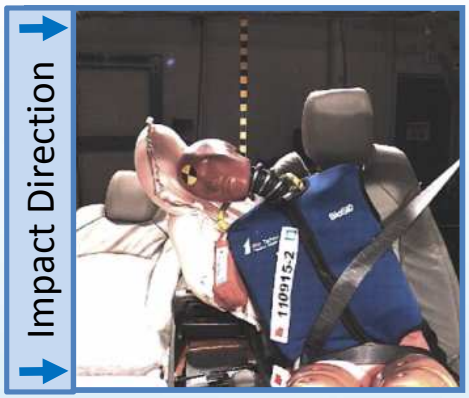
- The Front Center Airbag deploys out of the seat in a similar manner to an outboard side airbag with the following unique construction:
  - **Filled tubular “Figure 8" shape that resists lateral bending**
  - **External upper and lower tethers to curve the cushion toward the driver**
  - **Large inflated region adjacent the occupant’s head**
  - **Sealed unvented cushion for extended restraint (approximately ½ of peak pressure at 5 sec.)**
  - **Additional proprietary internal construction and seat mounting technologies.**

Deployment Mechanization

Passenger Side (Far Side) Impact



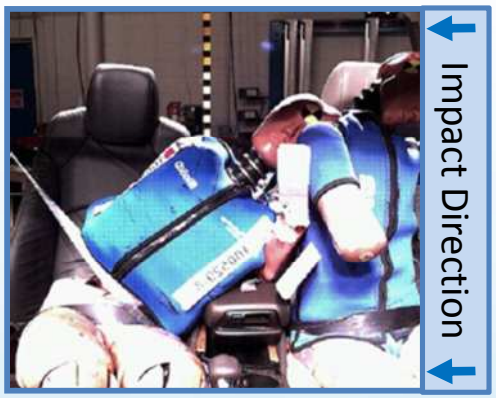
No Airbag



Front Center Airbag

- Provides Restraint

Driver Side (Near Side) Impact



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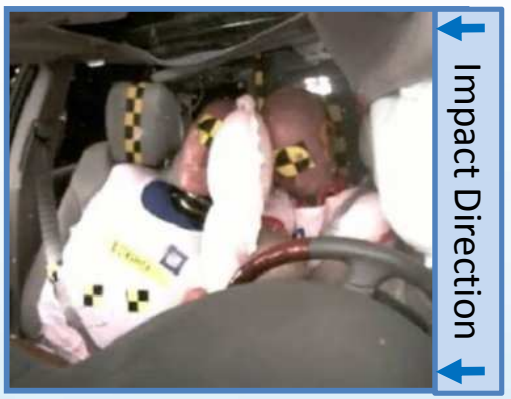
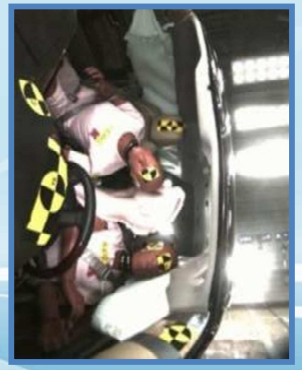


Front Center Airbag

– Provides Cushioning

- This technology activates in impacts above the deployment threshold for one or two front occupants:
  - Passenger side impacts
  - Driver side impacts
  - Rollovers (extended cushion stand time)
- The Front Center Airbag does not deploy in front and rear impacts.

Rollover



First Known Deployment In The Field

2013
GMC Acadia

- Near side impact from a vehicle running a stop sign.
- Impact followed by a rollover
- The Front Center Airbag and both roof rail airbags deployed.
- The GM employee was fine and after crawling out of his vehicle, assisted the driver that crashed into him until the emergency medical technicians arrived.

Performance Evaluations

- GM conducted evaluations for a broad range of potential occupant exposures:
  - In-position far side impacts
  - In-position near side impacts
  - Rollovers
  - Deployments with the arm, head, and torso in proximity to the airbag
  - Deployments with a rear facing child seat in proximity to the airbag

The Front Center Airbag

- Field Data Overview

Front Occupant Field Data

*Data from two NHTSA sources analyzed**

FARS – Fatal Analysis Reporting System

- A national census of fatalities

NASS-CDS – National Automotive Sampling System – Crashworthiness Data System

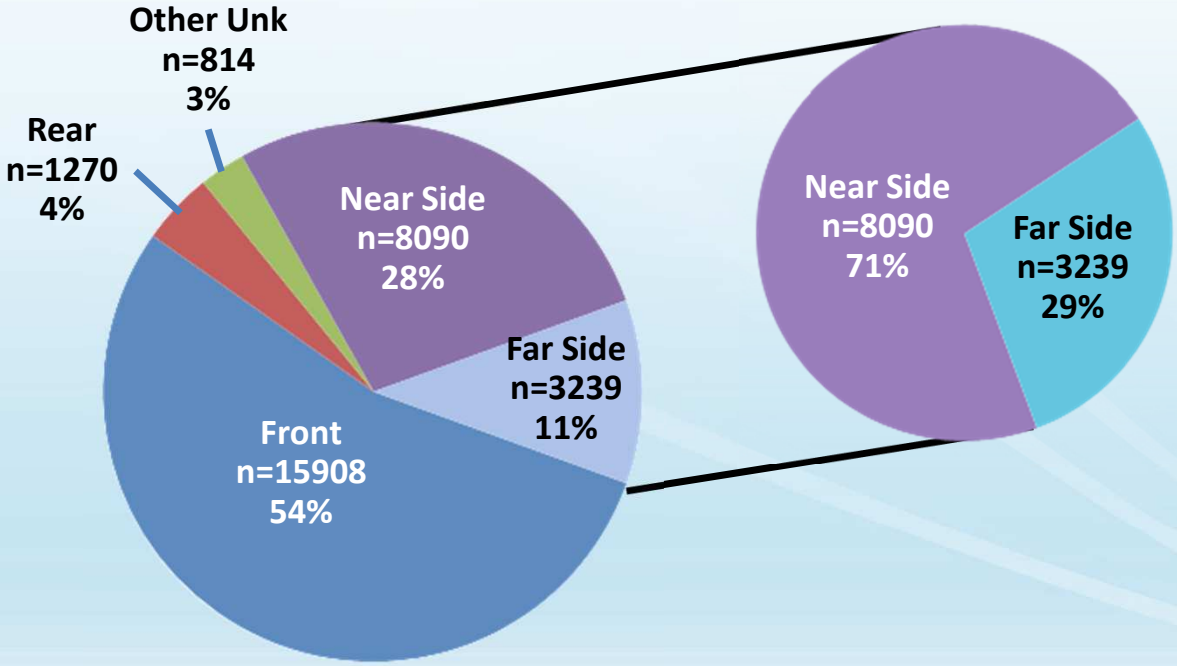
- A sampling of approximately 4,000 to 5,000 crashes annually, with detailed investigation
- GM engineers conducted in-depth case reviews and determined the primary injury contact sources**

*2004 – 2009, 1999 model year and newer vehicles

**AIS 3 and greater injuries, most severe for each body region

Front Occupant Field Data – FARS

*Belted Front Occupant Fatalities In Non-Rollover Crashes**

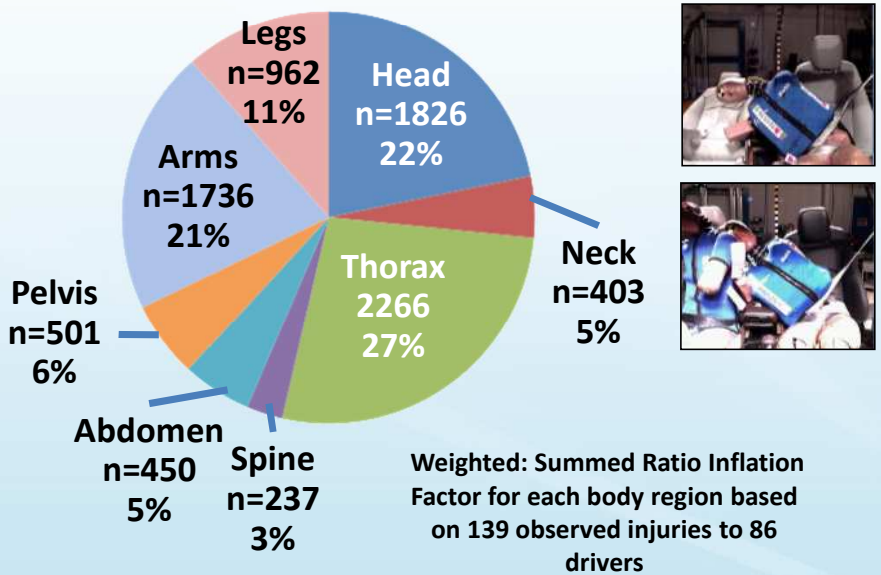


- 11% of belted outboard front occupant fatalities in non-rollover events occur to a far side occupant in a side impact.
- This is 29% of the fatalities in non-rollover side impacts.

*2004 – 2009, 1999 model year and newer vehicles

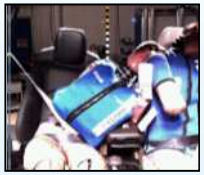
*Front Occupant Far Side Impact Field Data**

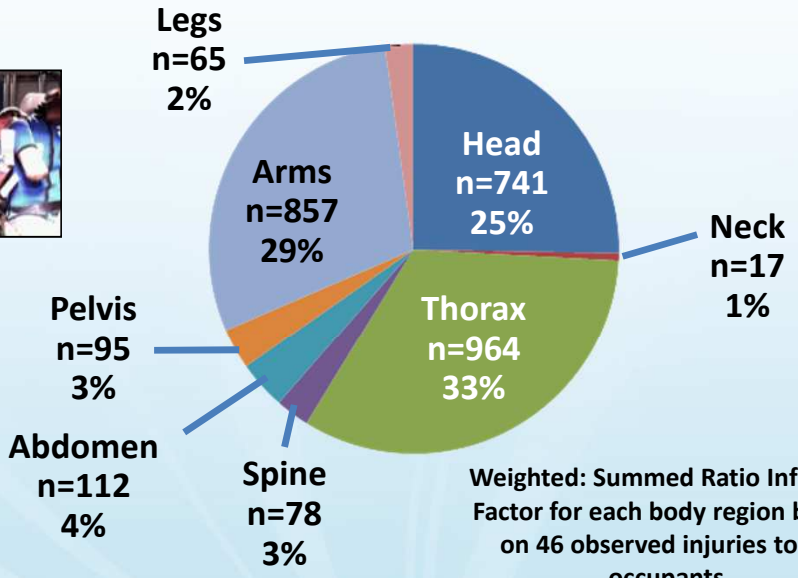
Injured Belted Driver Body Regions



Weighted: Summed Ratio Inflation Factor for each body region based on 139 observed injuries to 86 drivers

Injured Belted Passenger Body Regions





Weighted: Summed Ratio Inflation Factor for each body region based on 46 observed injuries to 33 occupants

- The head and thorax combined are the most frequently injured body regions.

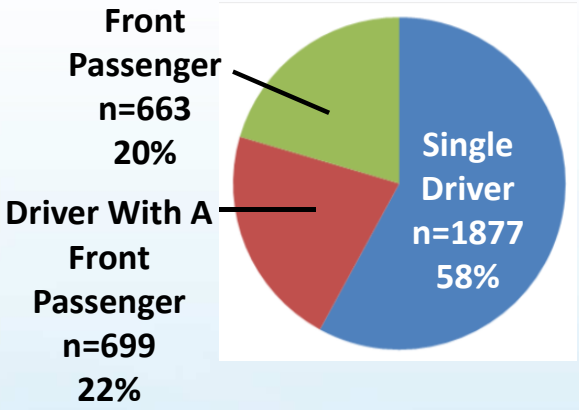
*Per NASS-CDS data analysis

The Front Center Airbag

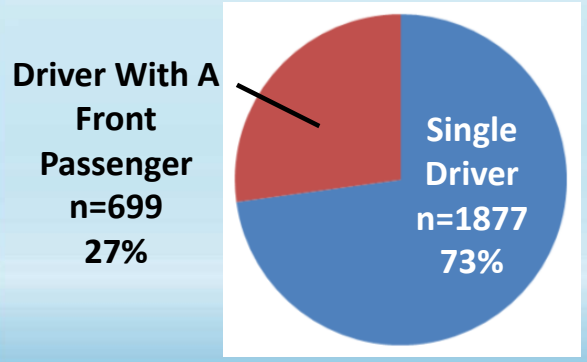
- The Single Driver Occupant –
  Field Data And In-Position Performance

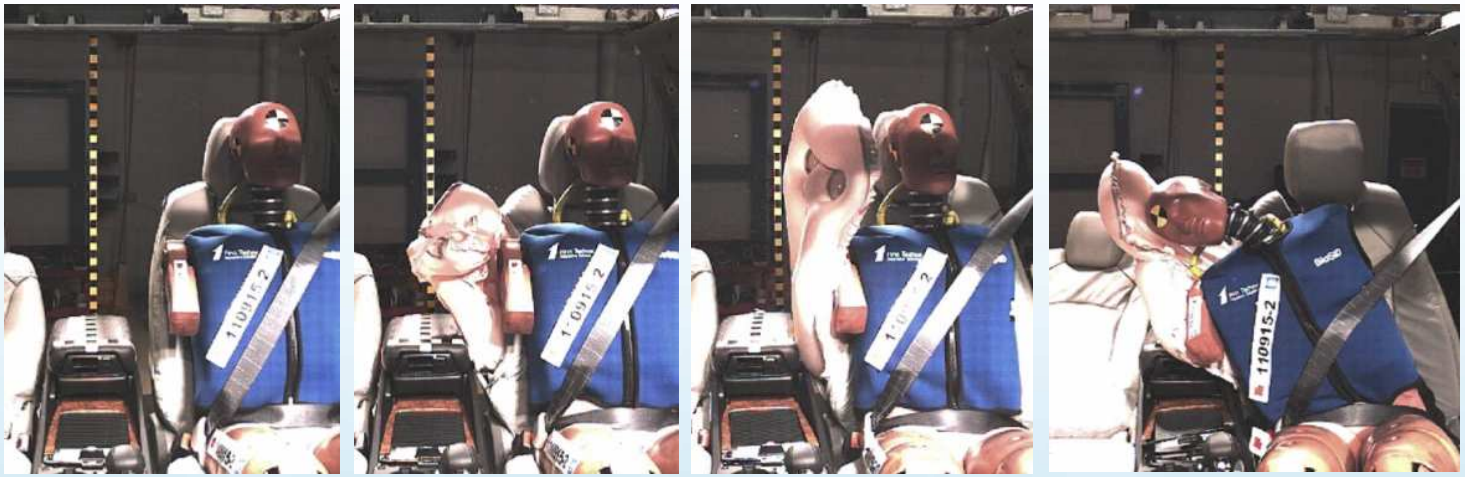
The Single Driver Occupant

Belted Front Occupant Far Side Fatalities In Non-Rollover Crashes – FARS*



Belted Driver Occupant Far Side Fatalities In Non-Rollover Crashes – FARS*

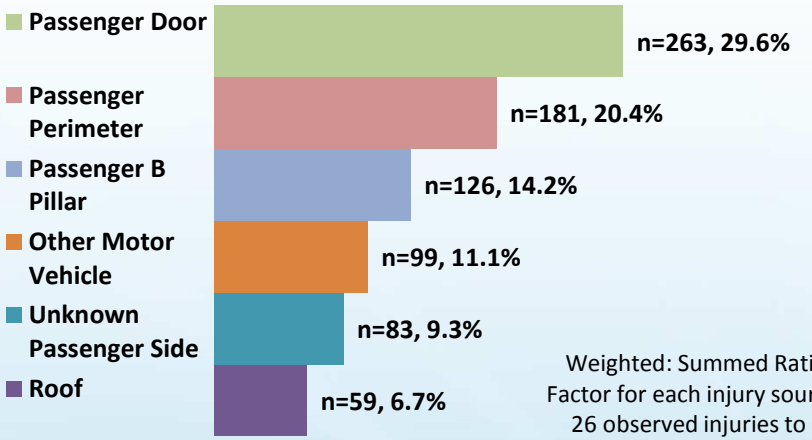




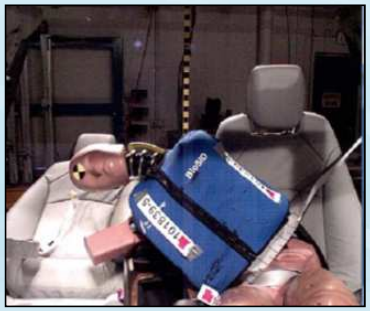
- 58% of the front occupant fatalities and 73% of the driver fatalities in far side impacts are to a single driver occupant.
- The Front Center Airbag provides restraint in this type of side impact to reduce cross-vehicle occupant movement.

*2004 – 2009, 1999 model year and newer vehicles

*Driver Head Injury Without Passenger Present**



Weighted: Summed Ratio Inflation Factor for each injury source based on 26 observed injuries to 26 drivers



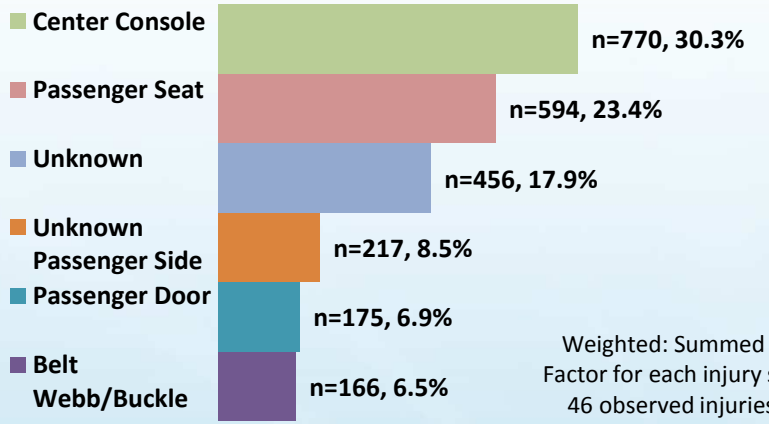
*Per NASS-CDS data analysis, 6 most frequent injury sources

Example Case Of A Driver Head Injury Attributed To The Far Side Door (2009-11-22-V01)

- AIS 5 brain stem compression (central)
- Single occupant, fatality with 19 coded injuries
- Contact marks on door identified with yellow tape

*Driver Torso Injury Without Passenger Present**

(Thorax, Spine, Abdomen, & Pelvis)



Weighted: Summed Ratio Inflation Factor for each injury source based on 46 observed injuries to 36 drivers

*Per NASS-CDS data analysis, 6 most frequent injury sources

Example Case Of Driver Torso Injuries Attributed To The Center Console (2007-47-164-V01)

- AIS 3 lumbar spine fracture (L4) and AIS3 pelvis fracture (right), both attributed to the center console
- Single occupant

Example Case Of A Driver Torso Injury Attributed To The Center Console (2008-75-240-V01)

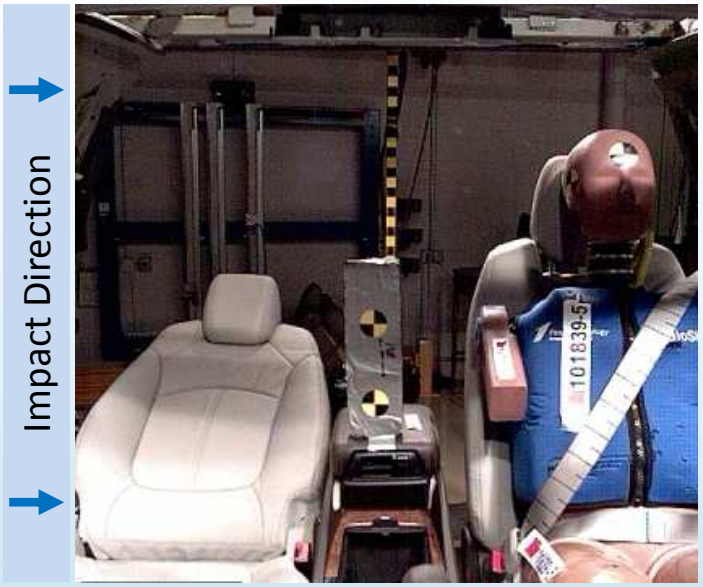
- AIS 4 lung contusion attributed to the center console.
- Numerous upper body and head injuries (AIS 5 to AIS3).
- Two front occupants present.

Example Of In-Position Restraint – Single Occupant

20 mph (32 kph) Oblique Pole Test

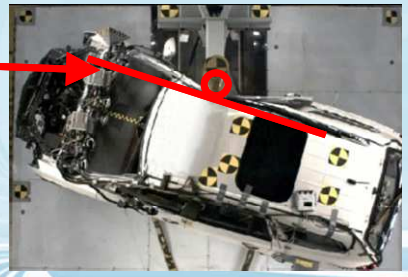
Passenger Side Pole Test Simulated on a Sled Without Intrusion

Example Of In-Position Restraint – Single Occupant



No Airbag

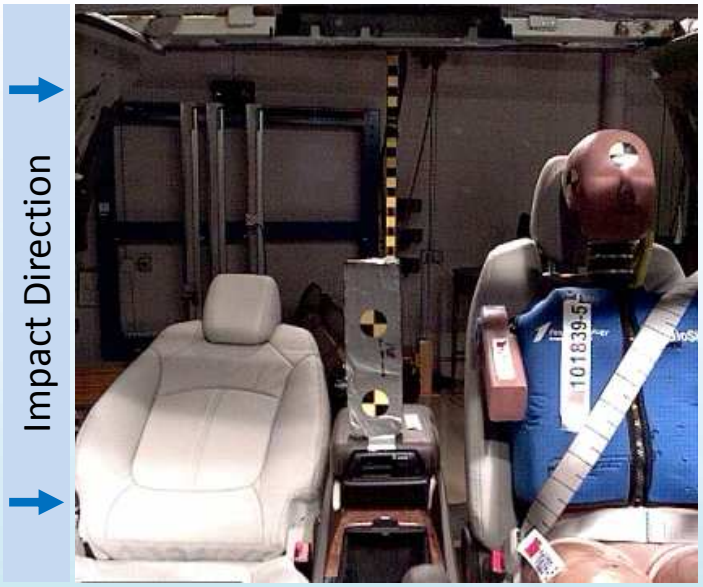
Front Center Airbag



Pole Intrusion

- The Front Center Airbag reduces cross-vehicle occupant movement.

Example Of In-Position Restraint – Single Occupant



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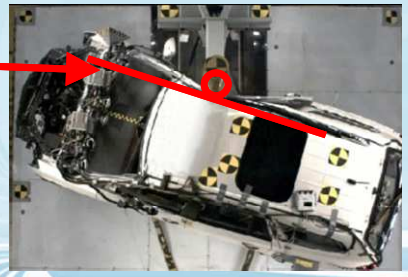

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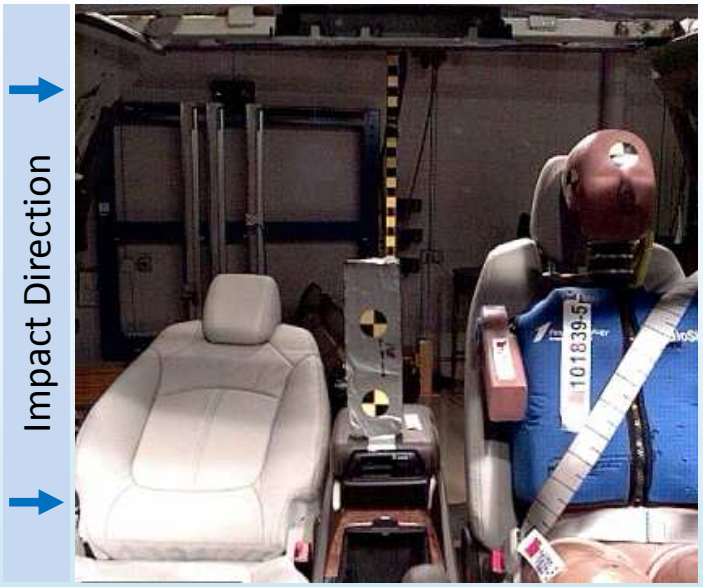

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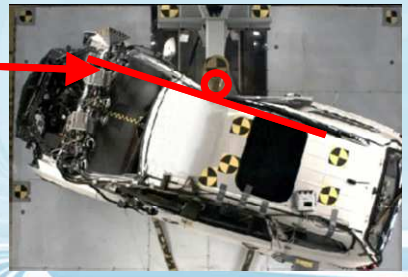

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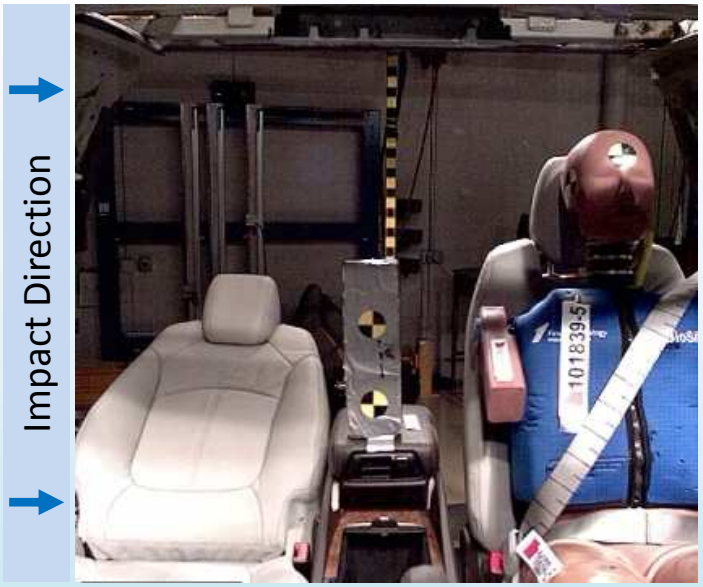

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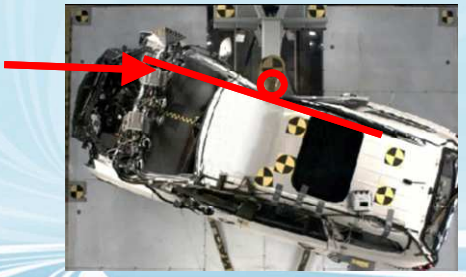

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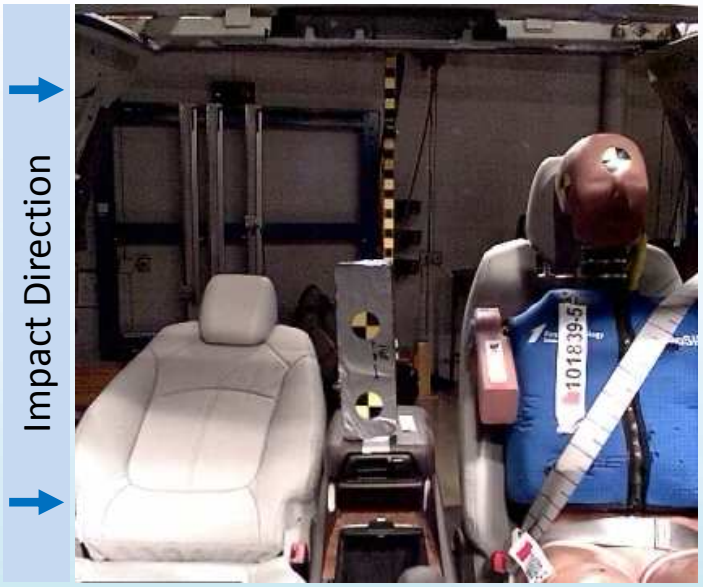

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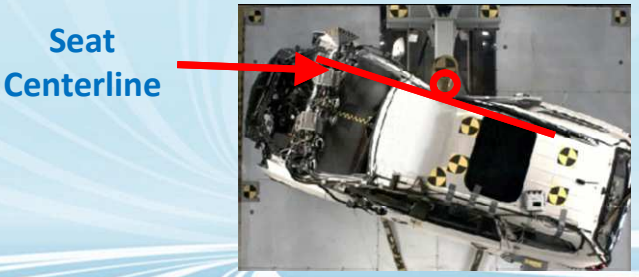

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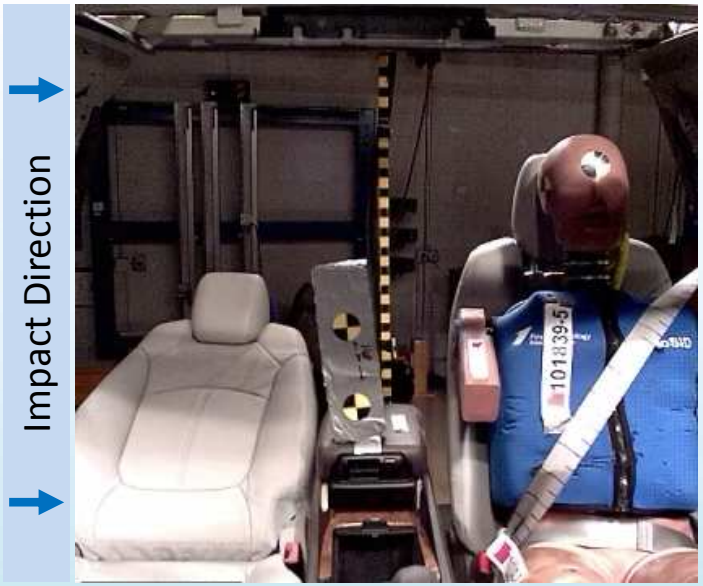
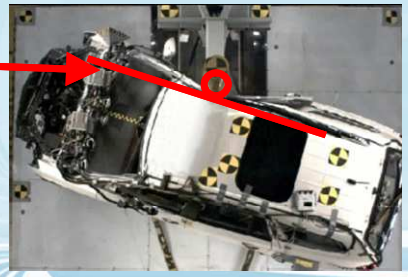


No Airbag

Front Center Airbag

Seat Centerline



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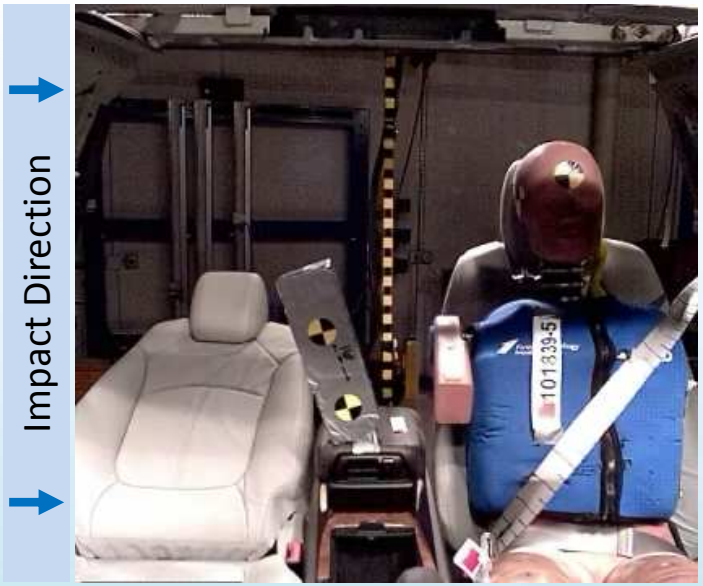

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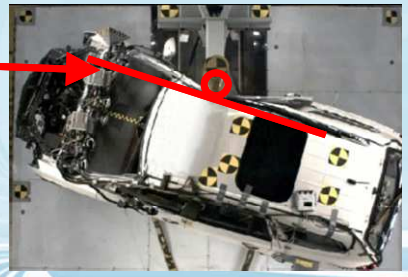

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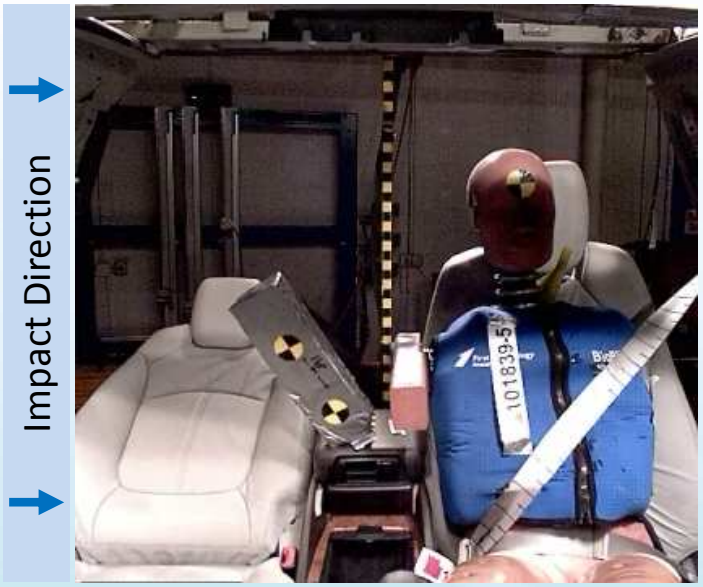

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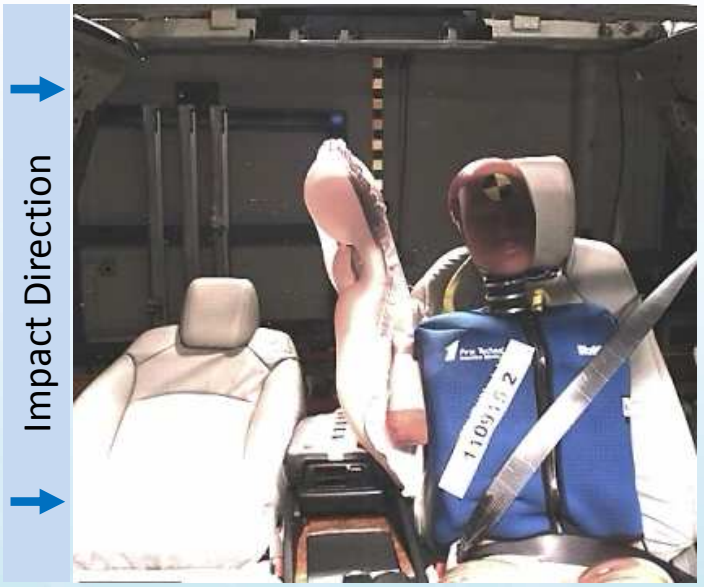

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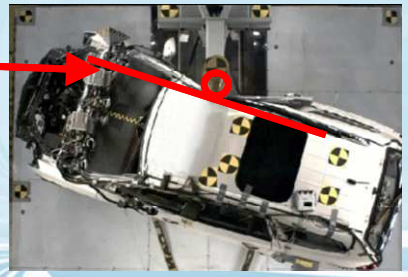

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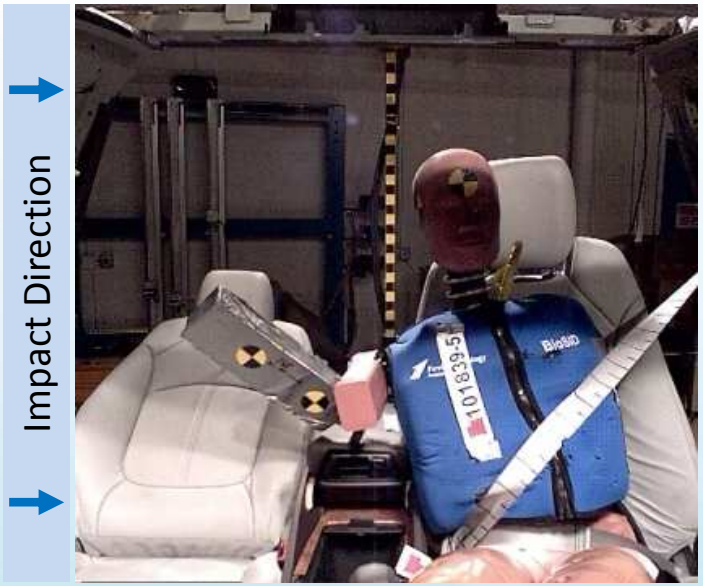
Example Of In-Position Restraint – Single Occupant



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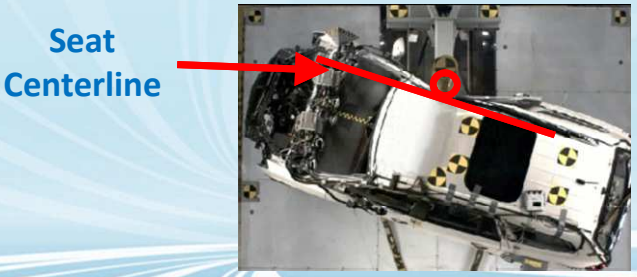

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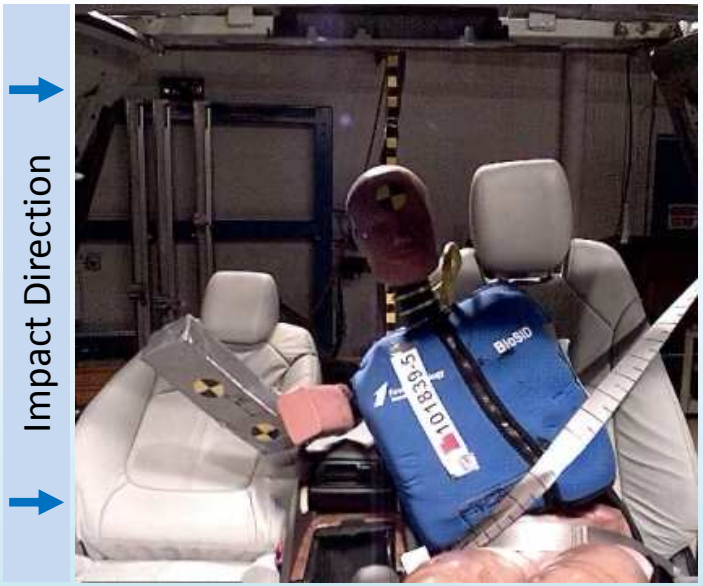

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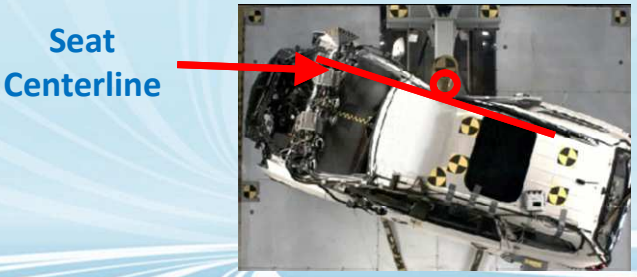

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Example Of In-Position Restraint – Single Occupant

No Airbag

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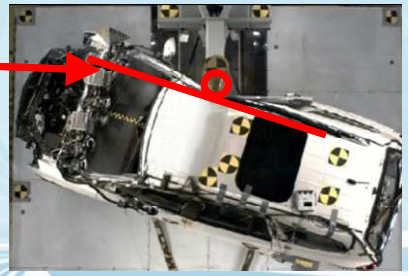

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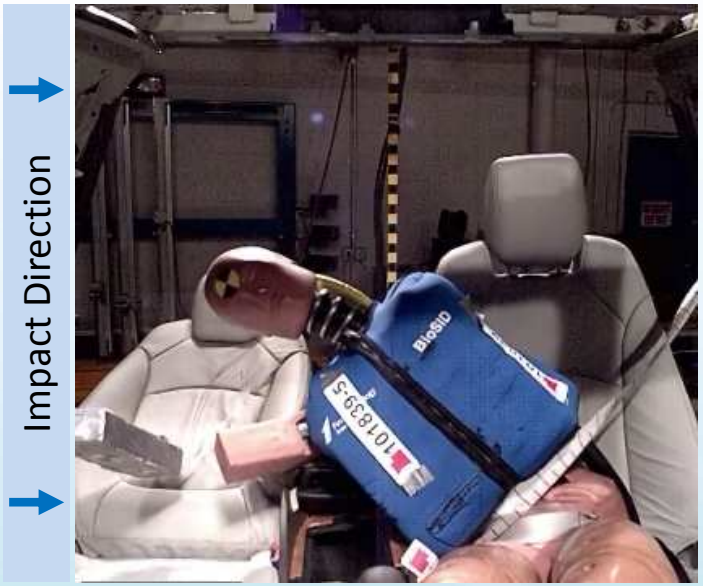

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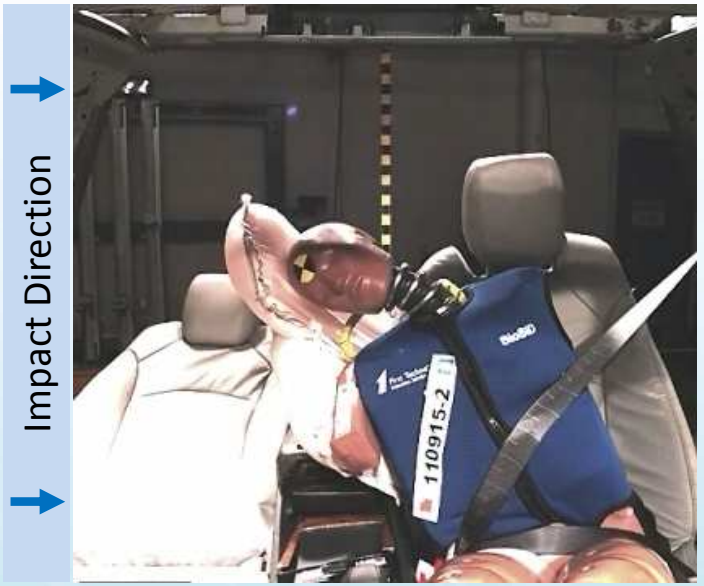

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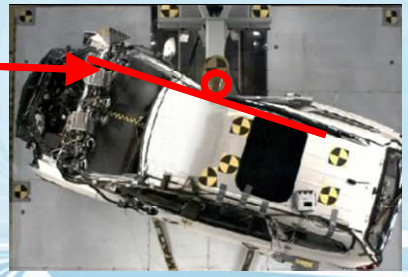

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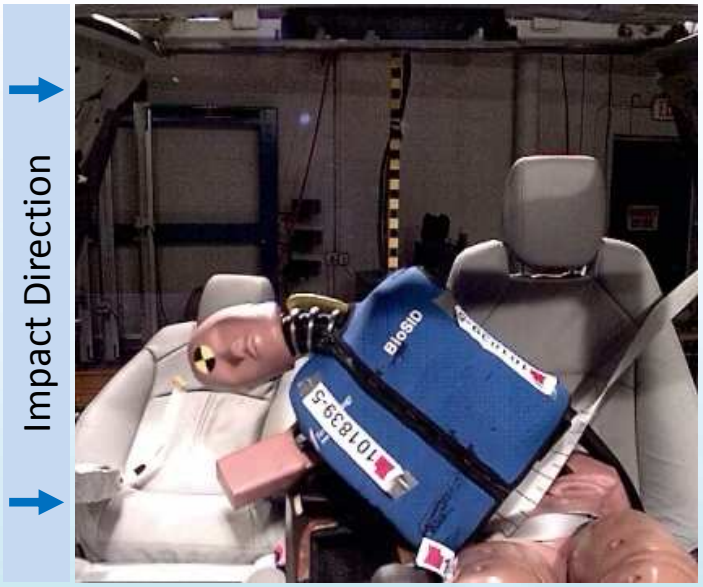

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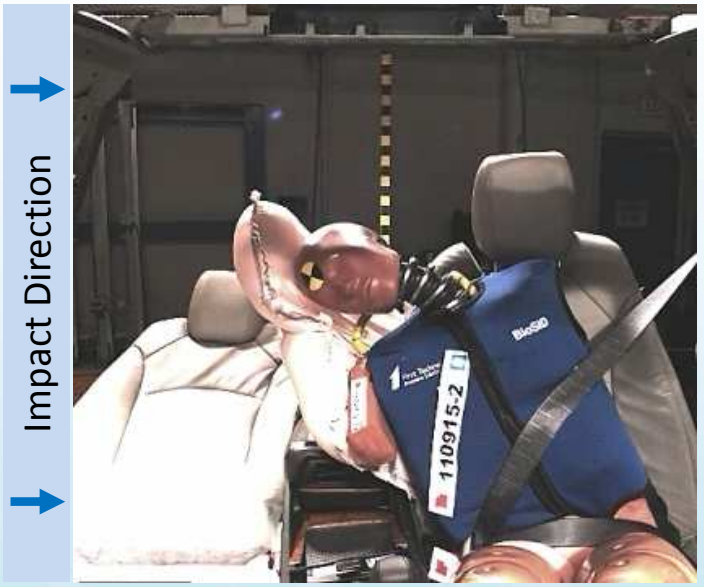

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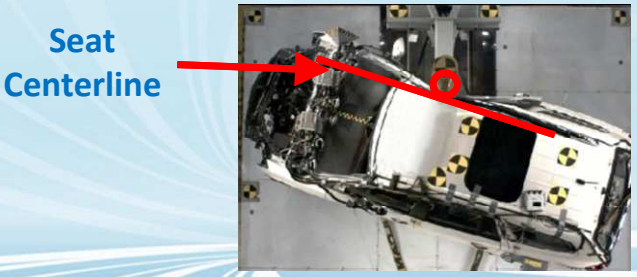

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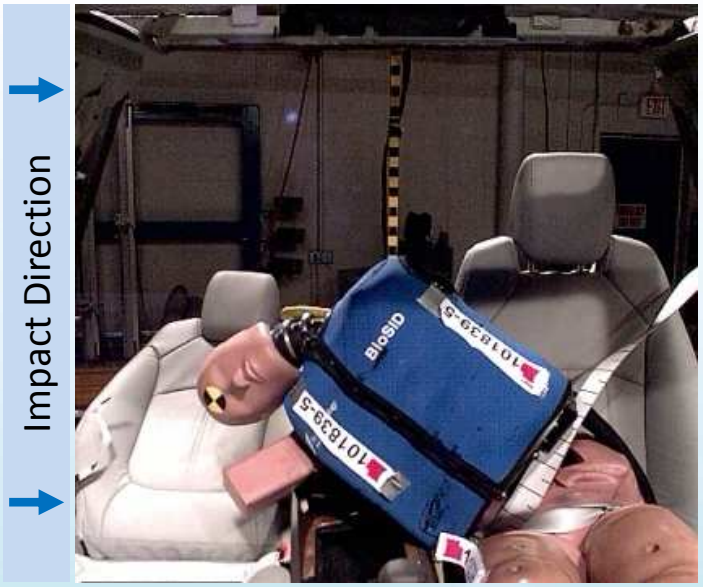

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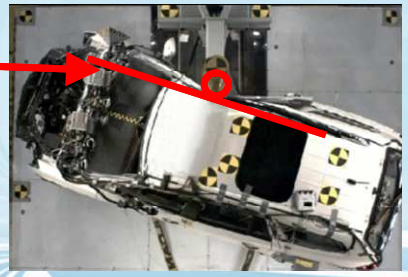
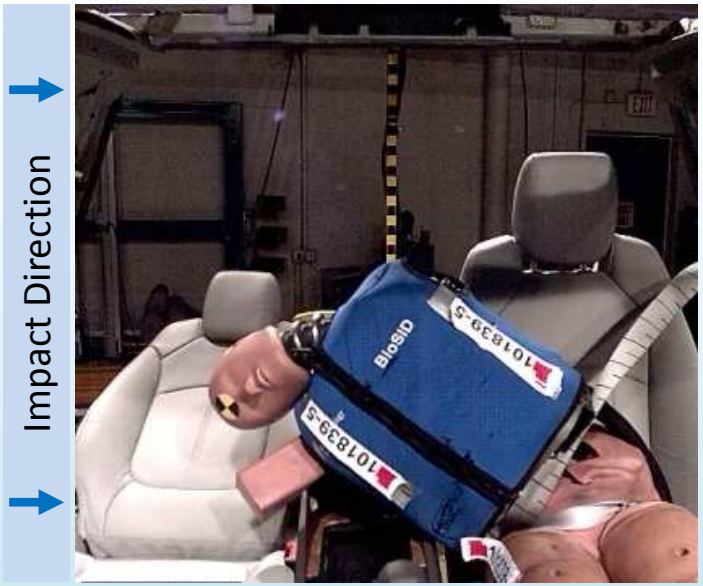


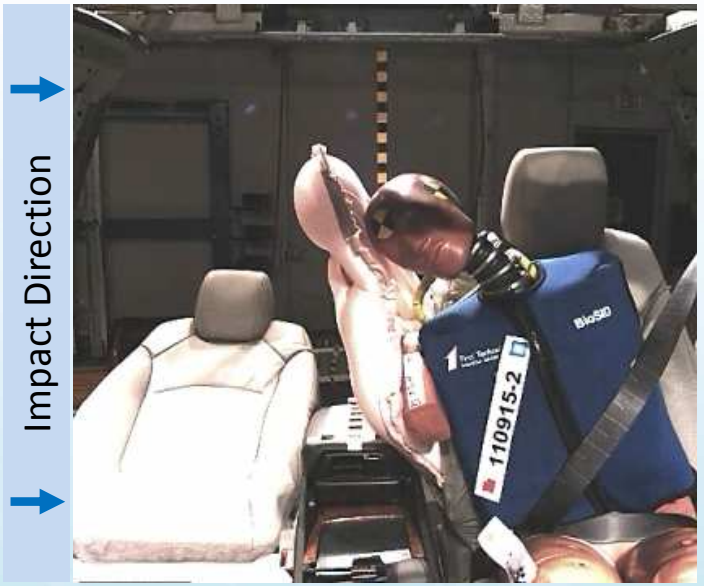
Pole Intrusion

- The Front Center Airbag reduces cross-vehicle occupant movement.

Example Of In-Position Restraint – Single Occupant



No Airbag



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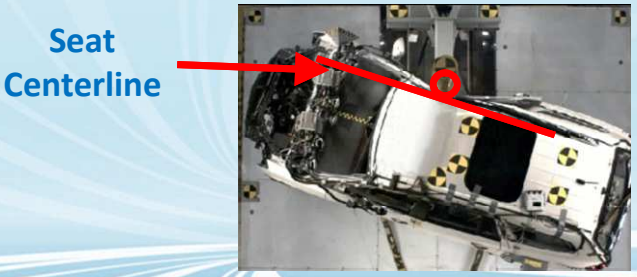

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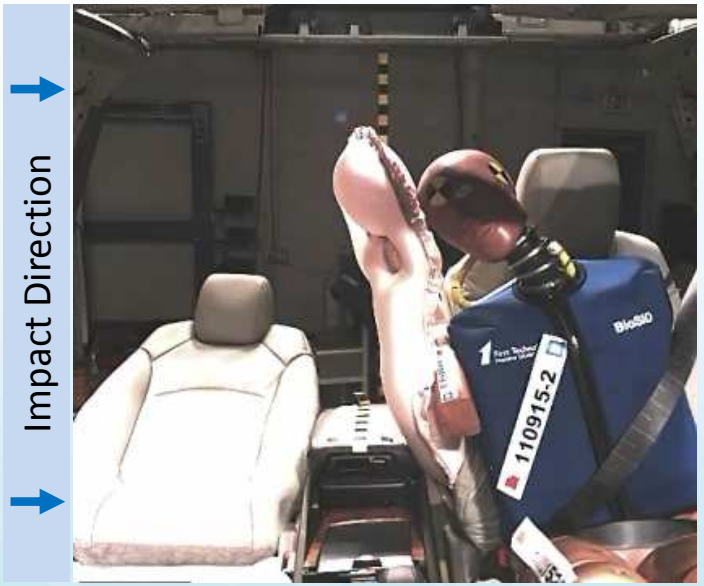

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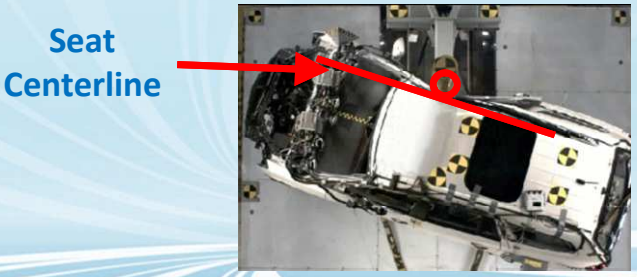

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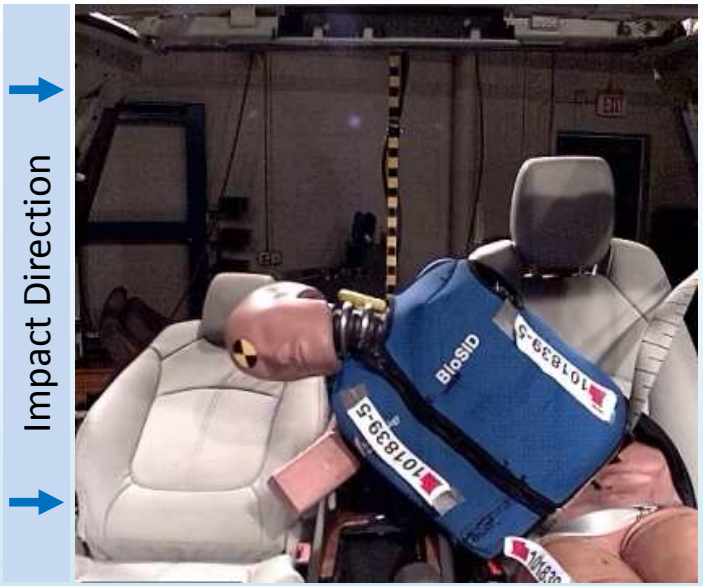

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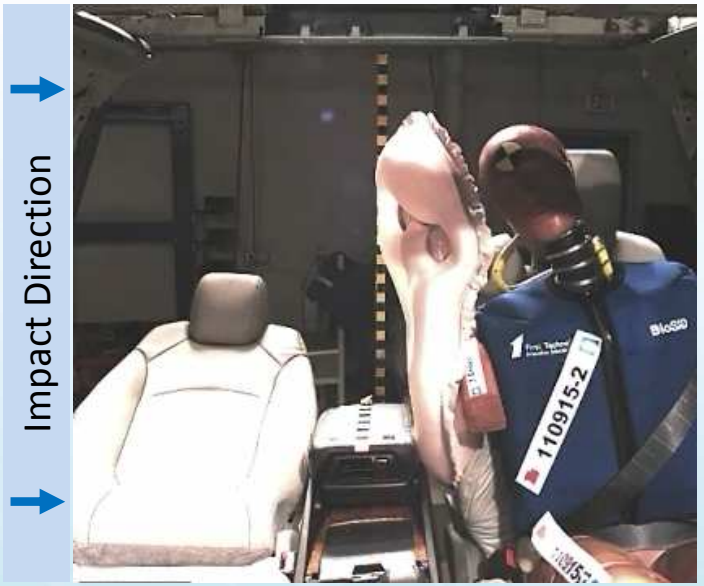

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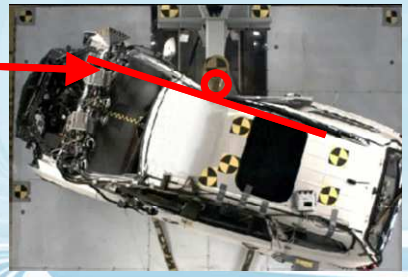
Seat Centerline



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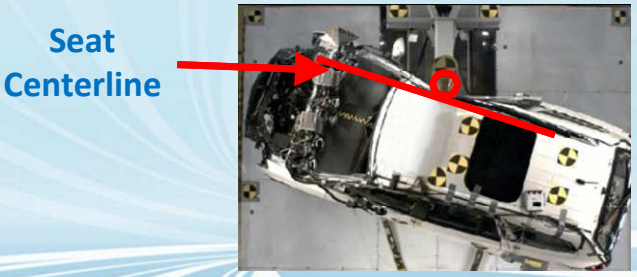

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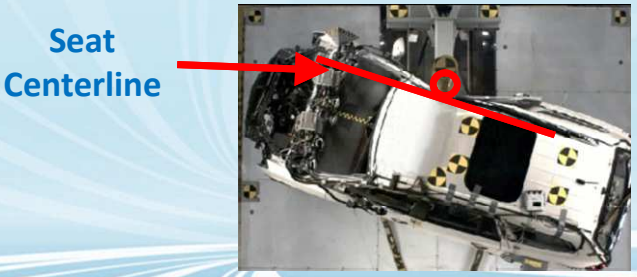

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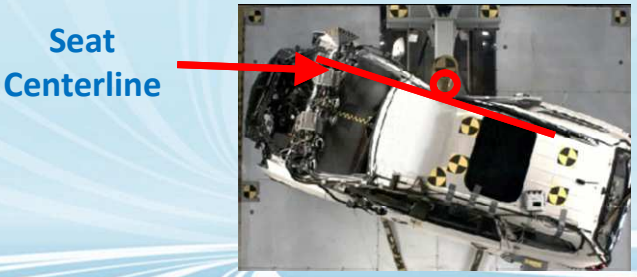

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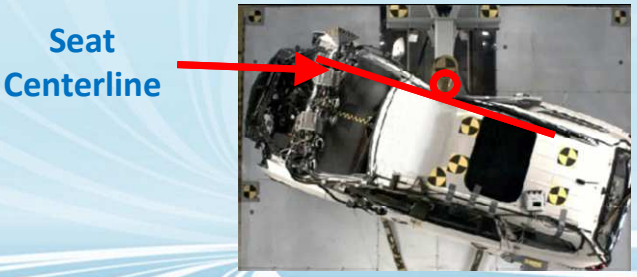


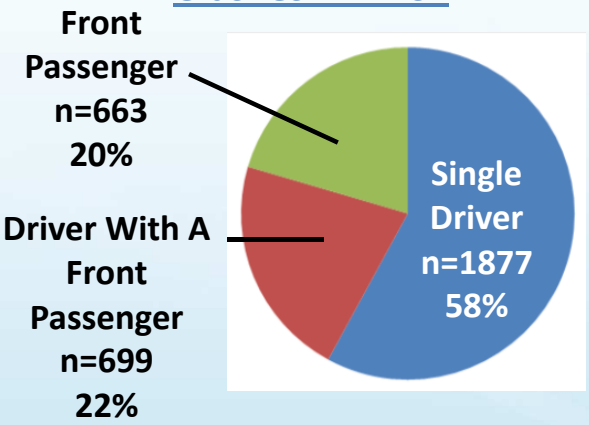
Pole Intrusion

The Front Center Airbag

- Two Front Occupants –
  Field Data And In-Position Performance

Two Front Occupants

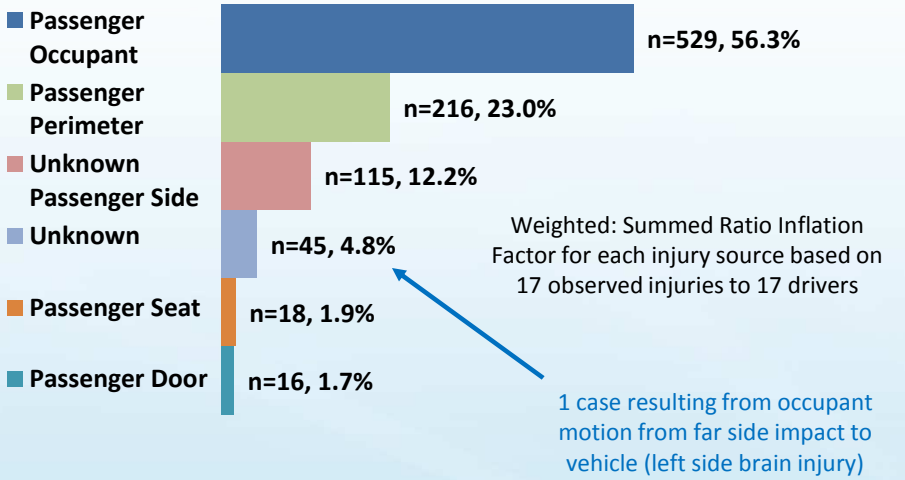
Belted Front Occupant Far Side Fatalities In Non-Rollover Crashes – FARS*



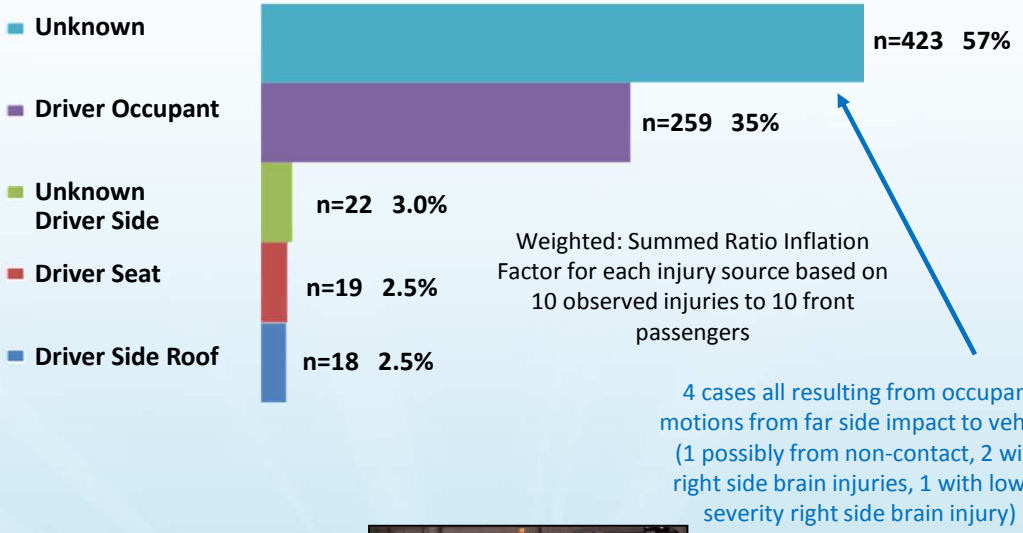
- 42% of the far side fatalities are to a front occupant that has a second adjacent occupant present.
- The Front Center Airbag can provide cushioning between the driver and the passenger.
- Both occupants can benefit from this single airbag.

*2004 – 2009, 1999 model year and newer vehicles

Driver Head Injury When Passenger Present*



Passenger Head Injury*



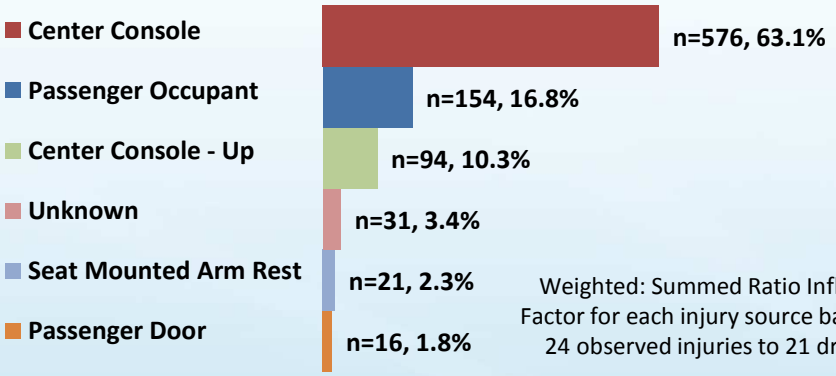
*Per NASS-CDS data analysis, 6 most frequent injury sources

Example Case Of A Driver Head Injury Attributed To The Passenger Occupant (2007-50-59-V01)

- AIS 4 cerebrum hemotoma /hemorrhage (right) attributed to other occupant.
- AIS 4 rib fractures with hemo/pneumothorax (right) attributed to center console.

Driver Torso Injury When Passenger Present*

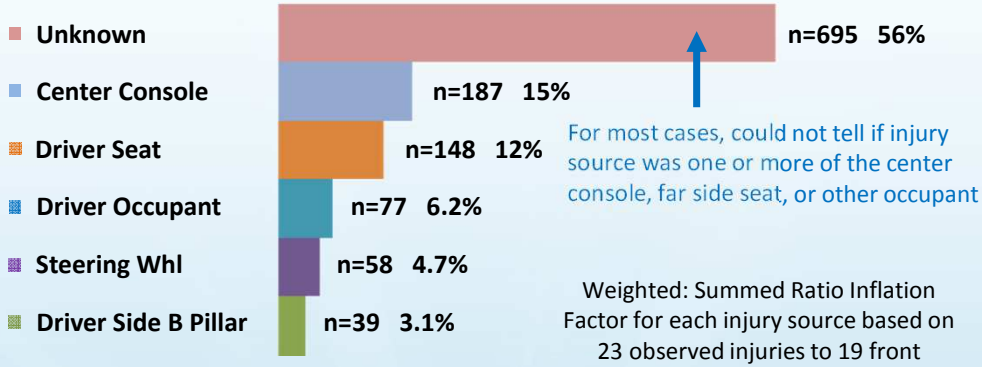
(Thorax, Spine, Abdomen, & Pelvis)



Weighted: Summed Ratio Inflation Factor for each injury source based on 24 observed injuries to 21 drivers

Passenger Torso Injury*

(Thorax, Spine, Abdomen, & Pelvis)



For most cases, could not tell if injury source was one or more of the center console, far side seat, or other occupant

Weighted: Summed Ratio Inflation Factor for each injury source based on 23 observed injuries to 19 front passengers

*Per NASS-CDS data analysis, 6 most frequent injury sources

Example Case Of A Driver Torso Injury Attributed To The Passenger Occupant (2005-09-072-V01)

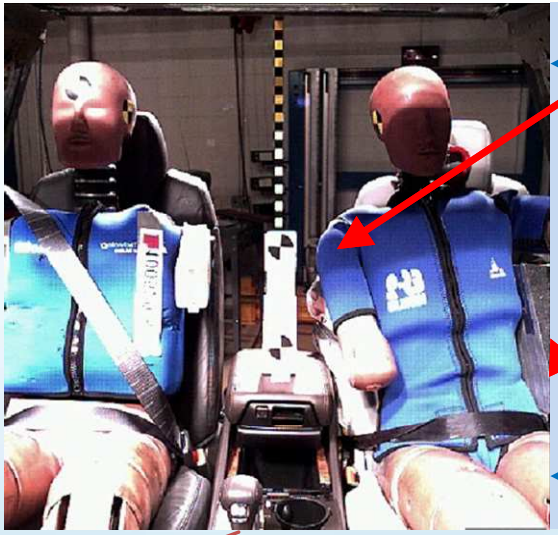
- AIS 3 rib fractures, flail chest (right) attributed to the passenger occupant.
- AIS 3 lung contusion (right) attributed to the passenger occupant.
- Passenger occupant has an AIS 3 head injury (left) attributed to the driver occupant.

Example Of In-Position Cushioning – Two Occupants

20 mph (32 kph) FMVSS-214 Oblique Pole Test

Driver Side Pole Test

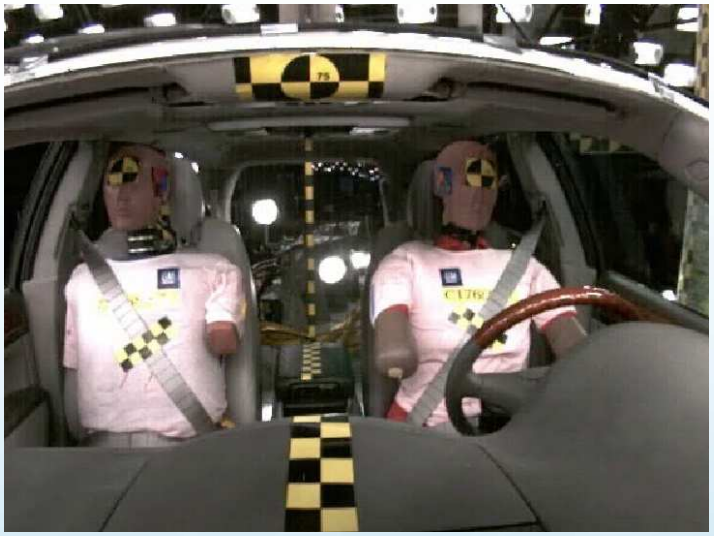
Example Of In-Position Cushioning – Two Occupants



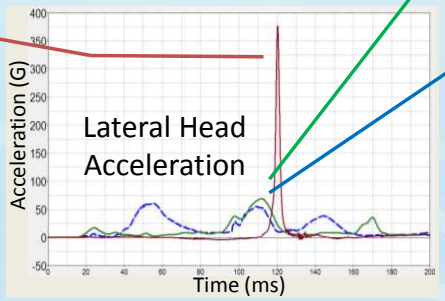
Shoulder Positioned Inboard

Impact Direction

Block



Sled Test With No Airbag And No Intrusion
558% Passenger Head Injury Criteria (HIC)*



Barrier Test With Front Center Airbag
56% & 22% HIC

- The Front Center Airbag provides cushioning from injury sources.

*558% HIC = 99+% risk of skull fracture / serious brain injury

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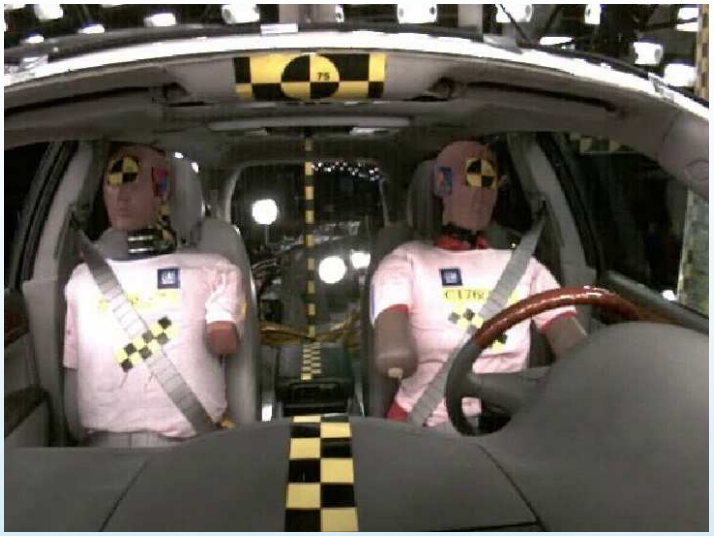

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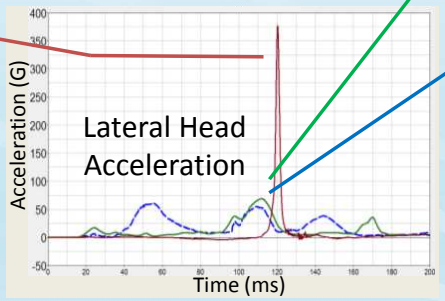

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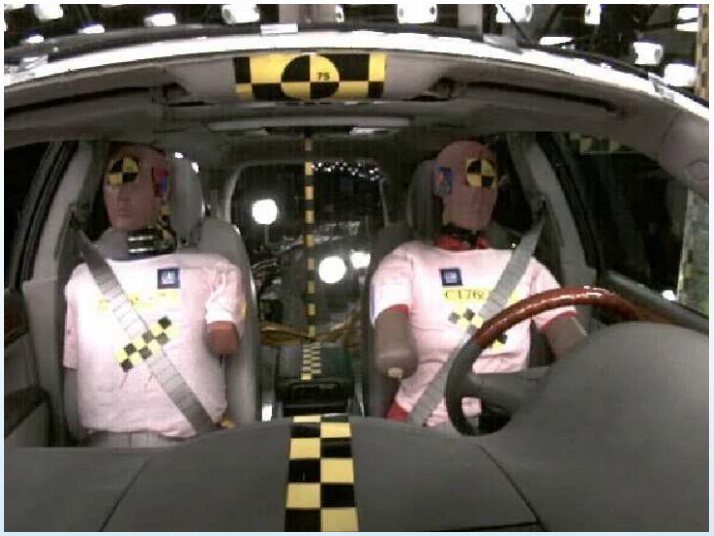

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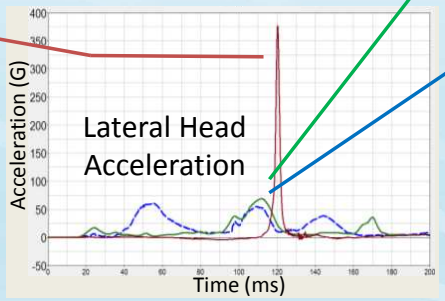

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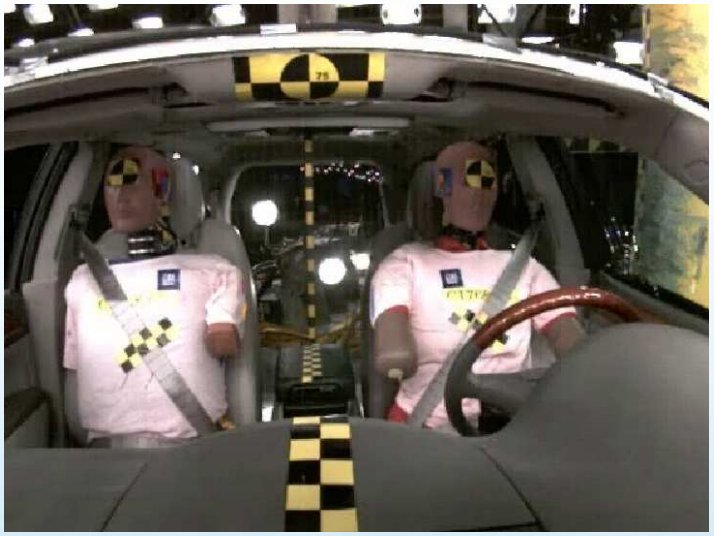

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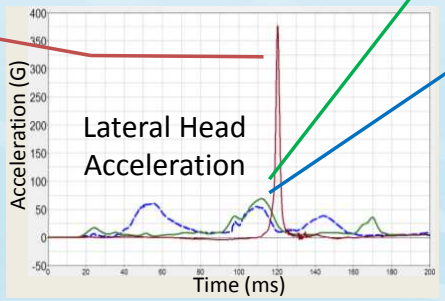

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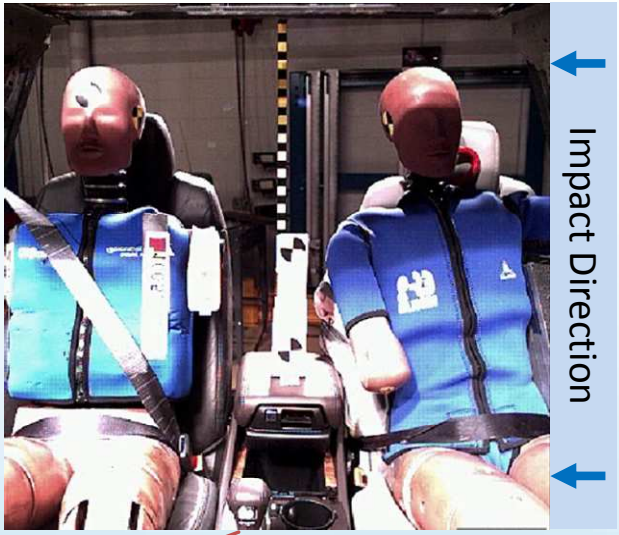

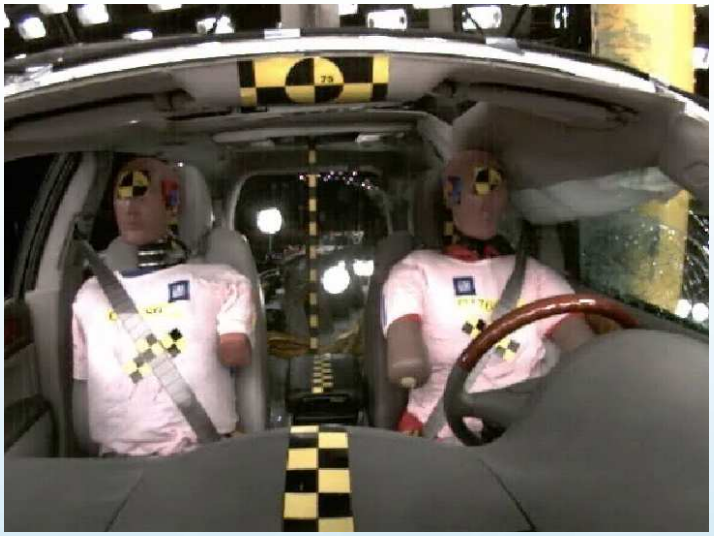

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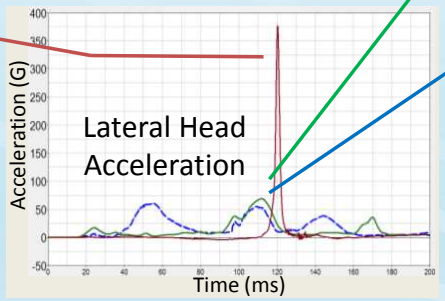

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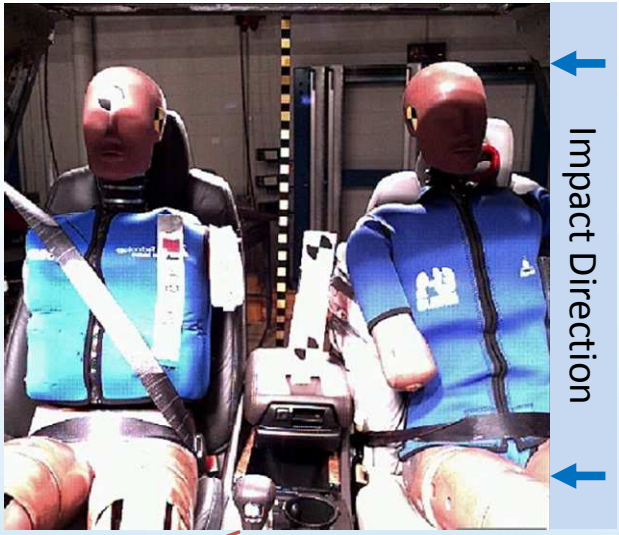

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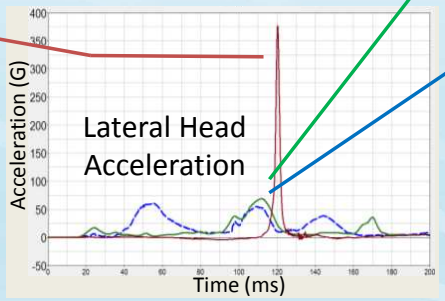

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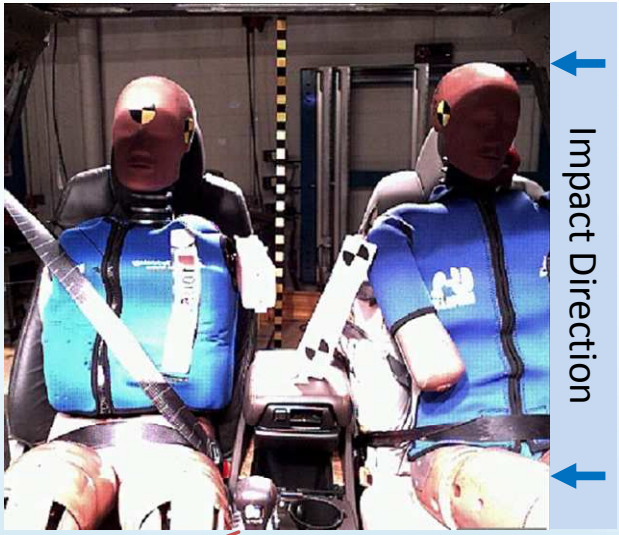

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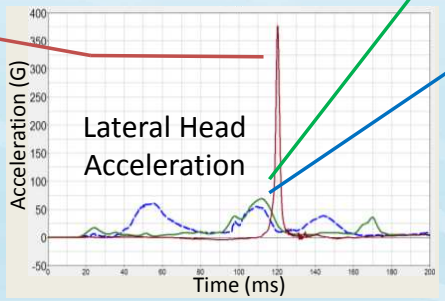

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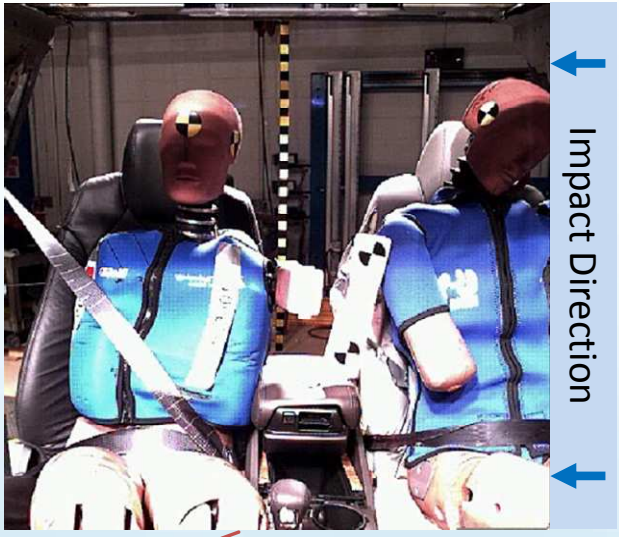

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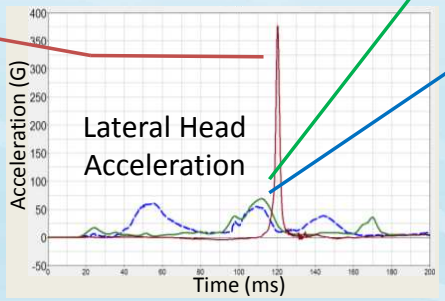

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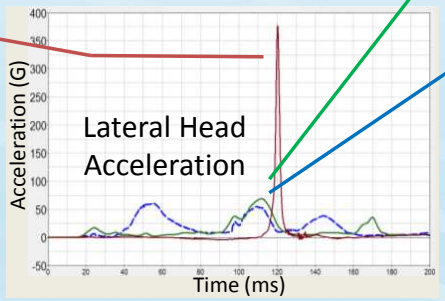

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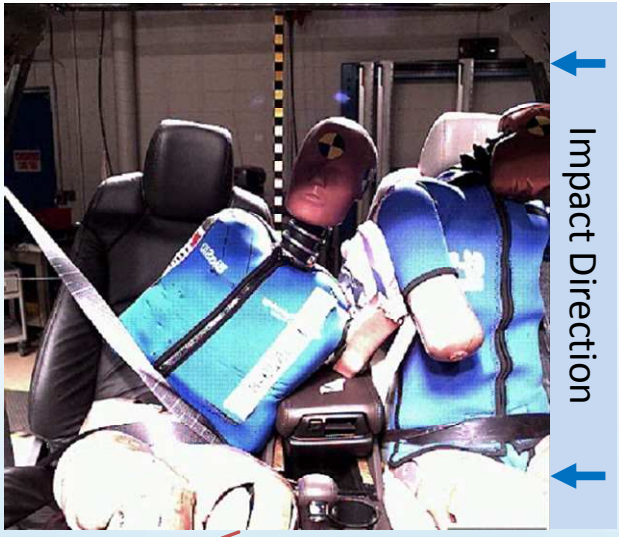

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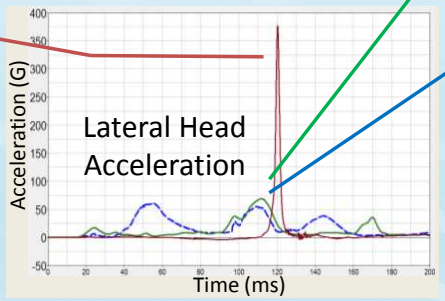

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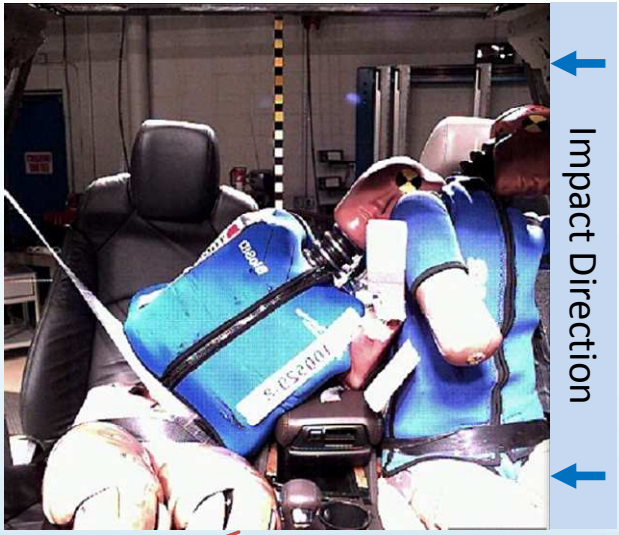

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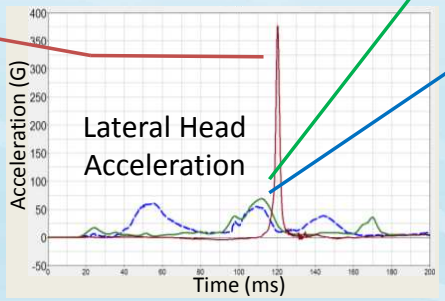

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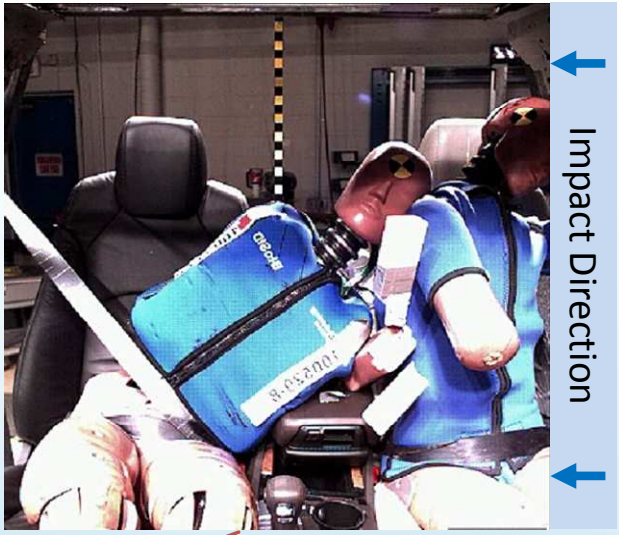

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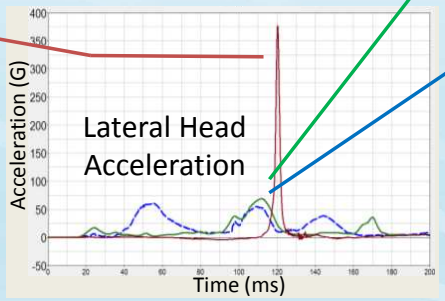

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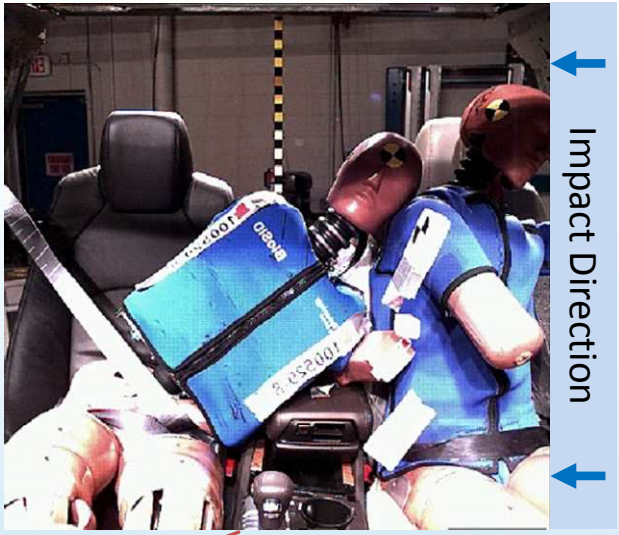

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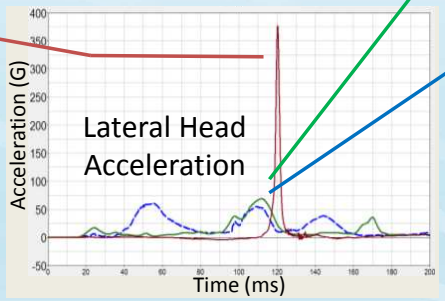

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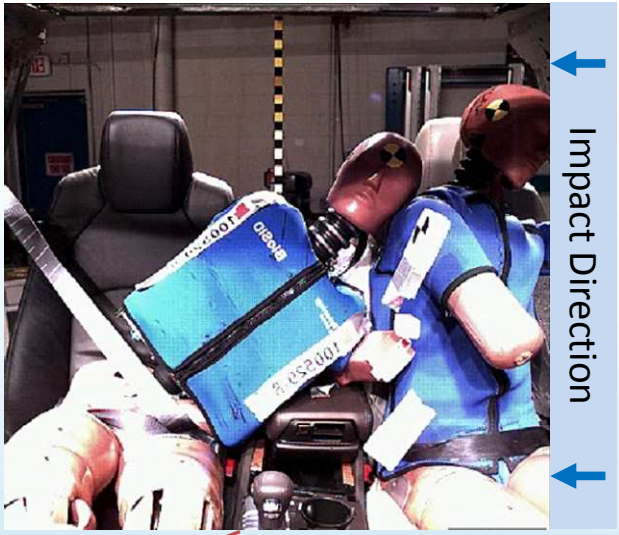

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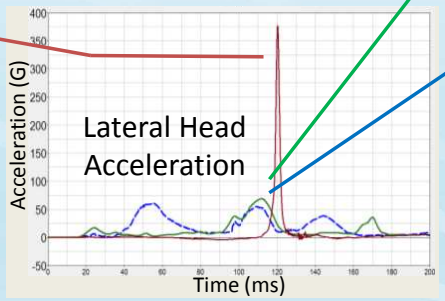

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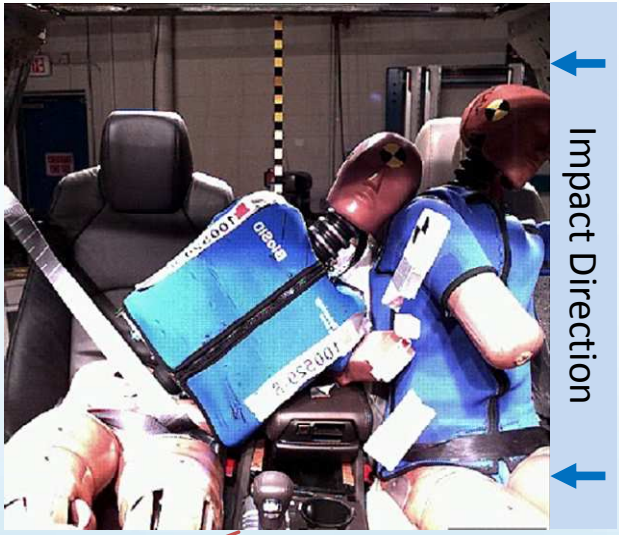
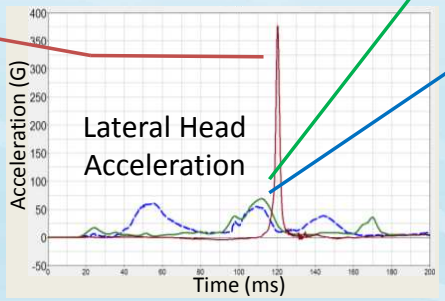
*99+% risk of skull fracture / serious brain injury

Example Of In-Position Cushioning – Two Occupants



Sled Test With No Airbag And No Intrusion
558% Passenger Head Injury Criteria (HIC)*



Barrier Test With Front Center Airbag
56% & 22% HIC

- The Front Center Airbag provides cushioning from injury sources.

*99+% risk of skull fracture / serious brain injury

Summary

- Based on extensive component, subsystem, and vehicle level testing / analysis, the Front Center Airbag has the potential to address many field injuries.
- Significant engineering effort has been undertaken by GM and Takata to minimize inflation induced injury risk during deployment.
- This technology is being implemented on the 2013 Buick Enclave, GMC Acadia, and Chevrolet Traverse.

Thank You